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Reply to: 3420

Date: March 13, 1993

Subject: A Biological Evaluation "A Field Test of the Efficacy of MCH in Preventing Douglas-fir Infestation by Douglas-fir Beetle."

To: Chief, WO

Enclosed is a biological evaluation entitled "A Field Test of the Efficacy of MCH in Preventing Douglas-fir Infestation by Douglas-fir Beetle."

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for LAURA B. FERGUSON
Director, State and Private Forestry

Enclosure

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3420
Report No. R4-93-03
March, 1993

A FIELD TEST OF THE EFFICACY OF MCH IN PREVENTING DOUGLAS-FIR INFESTATION BY DOUGLAS-FIR BEETLE

By

R. W. Thier[1]

Introduction

Douglas-fir beetle, Dendroctonus pseudotsugae Hopkins, is an important native insect pest of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco). Infestations often develop first in trees damaged by wind, fire, or defoliation then spread to adjacent susceptible living trees (Furniss and Orr 1978) where outbreaks may develop.

Douglas-fir beetle has one generation annually. Adult beetles attack trees throughout the summer. Beetles bore through the bark depositing eggs in the phloem. Following egg hatch, the larvae feed in the phloem eventually girdling the tree. The brood remains under the bark throughout the winter where they develop into adults and fly the following year (Furniss and Orr 1978).

Colonization of a tree is regulated by beetle produced pheromones plus compounds released by the tree (Vite 1970). These chemical messages are not only responsible for aggregation, or mass-attack of a tree, but also antiaggregation to stop attraction and potential overcolonization and competition among broods (Knopf and Pitman 1972, McGregor et al. 1984).

Various beetle management strategies have been investigated. Thinning and harvesting of Douglas-fir stands provide the best means to prevent Douglas-fir beetle infestations but in many cases cannot be timely applied or are environmentally undesireable. Insecticides have been proven effective but

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cannot be used everywhere, may be environmentally undesireable, or lack EPA registration. The use of synthesized pheromones has received increased attention for manipulating Douglas-fir beetle populations (Furniss and Orr 1978).

Pheromones for Douglas-fir beetle were first identified in the 1960's and 1970's. Their synthesis and testing soon followed. Compounds such as frontalin and alpha-pinene were tested and found to strongly attract adult beetles (Furniss et al. 1972, Knopf and Pitman 1972). Another pheromone, 3-methyl-2-cyclohexen-1-one (MCH), proved to be antiaggregative to Douglas-fir beetle (Furniss et al. 1974, Rudinsky et al. 1972). Controlled release formulations of MCH were further proven effective in reducing Douglas-fir beetle infestations in fallen trees (Furniss et al. 1977, McGregor et al. 1984).

This investigation field tested MCH on standing uninfested Douglas-fir where beetles were present. The objectives of the field test were to determine: (1) the efficacy of MCH to prevent Douglas-fir beetle infestation in the presence of Douglas-fir beetle baits containing both frontalin and alpha-pinene, and (2) the efficacy of MCH to prevent Douglas-fir beetle infestation in Douglas-fir stands.

Methods and Materials

Treatments were tested using a randomized block design. Treatments included (1) Douglas-fir beetle bait, (2) MCH, (3) Douglas-fir beetle bait and MCH, (4) experimental control. Each treatment was applied to a 2.5 acre block and replicated five times resulting in twenty 2.5-acre plots. Plots were square, 5 chains on a side, and spaced 5 chains apart.

The four plots within a replicate were planned to be as uniform as possible to avoid stand effects on the treatment. Douglas-fir was to constitute 75% or more of the stand and plots were to contain 3-10 infested trees. Perfect uniformity was not essential because treatment effects were to be based on percent of trees infested.

MCH and baits were obtained from Phero Tech Inc.. Baits contained a 1:1 mixture of frontalin and alpha-pinene. MCH was loaded in plastic bubble caps which daily released 0.5 mg of MCH.

MCH bubble caps were evenly spaced throughout the plots at the rate of 40 caps/acre in a grid pattern. Grid spacing was approximately 1/2 ch X 1/2 ch. Each cap was stapled to the bark, 6-7 feet above ground, on the north side of the tree that was closest to the grid coordinate regardless of tree species. Spacing was maintained as closely as possible.

1/0.5 ac!

Five Douglas-fir beetle baits were used in each of the baited plots. Baits were applied 6-7 feet above ground on the north side of 10" DBH or larger Douglas-fir. One bait was placed at the center of the plot and one each midway along the sides of the plot approximately 1 ch from the boundary of the plot.

In fall 1989, test plots were established in the Adams Creek drainage on the Weiser Ranger District, Payette National Forest, Idaho. Douglas-fir trees in this area had experienced chronic Douglas-fir beetle infestation for many

years. Installation was planned for the following spring but, because of delays in project funding and product availability, project implementation was delayed until spring 1991 in advance of beetle flight.

After beetle flight, in fall 1991, we examined all trees 5 inches DBH and larger on all plots. Species and diameter of each tree examined was tallied and each Douglas-fir was categorized as uninfested, killed prior to 1990, killed in 1990, or currently infested - 1991. Following data summarization analysis of variance was planned to detect statistical differences.

Results and Discussion

size? age?

Douglas-fir dominated our plots, on average exceeding 84% Douglas-fir for each replicate, but two plots failed to meet the 75% Douglas-fir standard (Table 1). These two plots were only 69% and 70% Douglas-fir. Likewise, the variability with respect to percentage Douglas-fir was higher in replicates 4 and 5 than replicates 1, 2, and 3.

Stocking density ranged from 26.4 trees/acre to 139.2 trees/acre (Table 1). Average stocking density exceeded 41.2 trees/acre among the five replicates. Stocking density was not uniform among plots which, like species composition, was undesireable and may be a source of error.

Table 1. Stand characteristics before a test of the efficacy of MCH to prevent beetle infestation, Payette National Forest, Idaho, U.S.A, 1991.

Treatment	Replicate 1	2	3	4	5	$\bar{X}$	S.D.
			Percentage Live Douglas-fir				
Douglas-fir beetle bait	91	100	97	70	100	91.6	12.62
MCH	100	100	100	96	97	98.6	1.95
Bait + MCH	100	100	98	83	69	90.0	13.73
Control	89	100	99	87	100	95.0	6.44
Combined $\bar{X}$	95.0	100	98.5	84.0	91.5		
S.D.	5.83	0	1.29	10.80	15.07		
			Live Trees/Acre				
Douglas-fir beetle bait	58.8	50.0	46.8	109.2	63.6	65.7	25.24
MCH	47.2	37.2	43.6	89.2	31.6	49.8	22.84
Bait + MCH	72.8	37.6	69.2	30.8	43.2	50.7	19.07
Control	139.2	44.4	45.6	45.6	26.4	60.2	44.89
Combined $\bar{X}$	79.5	42.3	51.3	68.7	41.2		
S.D.	41.15	6.10	12.01	36.66	16.50		

The mean diameter of live Douglas-fir on plots prior to treatment ranged from 10.2" DBH to 20.2" DBH (Table 2). Although we applied no statistical tests, it appears that little difference exists among plots within a replicate with respect to the diameter of live Douglas-fir. On average, the live Douglas-fir on those plots treated with MCH alone were the largest and those on the bait only plots were the smallest.

Table 2. Diameter of live Douglas-fir before a test of the efficacy of MCH to prevent beetle infestation, Payette National Forest, Idaho, U.S.A, 1991.

Treatment	Replicate					Avg.
	1	2	3	4	5	
Douglas-fir beetle bait						
$\bar{X}$	10.7	10.8	15.5	10.2	15.0	12.44
S.D.	5.08	4.22	7.10	6.08	8.06	
MCH						
$\bar{X}$	15.4	13.9	19.0	13.0	20.2	16.30
S.D.	5.50	5.90	8.04	6.13	9.87	
Bait + MCH						
$\bar{X}$	13.0	12.4	16.6	17.5	16.6	15.22
S.D.	6.42	4.39	6.19	7.18	10.46	
Control						
$\bar{X}$	11.2	11.5	15.3	13.8	18.2	14.00
S.D.	4.08	5.13	6.61	8.31	6.05	
Combined						
Avg.	12.58	12.15	16.60	13.63	17.50	

Levels of Douglas-fir beetle activity on the plots before the test in 1990 were disappointingly low (Table 3). The majority of plots had no activity present in 1990. Only three of the 20 plots had any Douglas-fir beetle activity; however, the study plan required 3-10 infested trees on each plot. This violation of our study plan was probably the single most important factor preventing testable results.

During the evaluation we found few trees infested in 1991, even on the baited plots, again indicative of very low beetle populations in the area. Trees on three of the five baited plots sustained no attacks where one would expect at least the baited trees to be infested (Table 3). Without beetle attacks in our control plots, and little activity in the bait plots, no treatment effects could be shown and further analysis became pointless. On average, baited plots

sustained the most mortality in 1991, albeit low, and had a 200% increase in activity from 1990 to 1991 (Table 3). These were the only plots to experience an increase in activity. The MCH plots were the only plots that, on average, experienced a decrease in Douglas-fir beetle caused mortality. The trend was not consistent among the MCH plots where three of the four replicates experienced no mortality in 1990 or 1991 (Table 3). One cannot state that MCH was responsible for decreased activity. The other treatments, bait plus MCH and untreated control, experienced no attacks in 1990 and 1991. Again, no inferences can be made.

Table 3. Numbers of Douglas-fir killed per acre by Douglas-fir beetles before and during a test of the efficacy of MCH to prevent beetle infestation, Payette National Forest, Idaho, U.S.A, 1991.

	Replicate					
	1	2	3	4	5	Avg.
DFB bait						
Prior to 1990	0	0.4	0	0	0.4	0.16
1990	0.4	1.2	0	0	0	0.32
1991	1.2	3.6	0	0	0	0.96
% change, 1990-91	200	200	0	0	0	200.0
MCH						
Prior to 1990	0	0.4	0	0	0	0.08
1990	0	0.8	0	0	0	0.04
1991	0	0	0	0	0	0.0
% change, 1990-91	0	-100	0	0	0	-100.0
Bait + MCH						
Prior to 1990	0.4	0	0	0	2.0	0.48
1990	0	0	0	0	0	0.0
1991	0	0	0	0	0	0.0
% change, 1990-91	0	0	0	0	0	0.0
Control						
Prior to 1990	0	0	0	2.8	0.4	0.64
1990	0	0	0	0	0	0.0
1991	0	0	0	0	0	0.0
% change, 1990-91	0	0	0	0	0	0.0
Combined						
Prior to 1990	0.1	0.2	0	0.7	0.7	0.34
1990	0.1	0.5	0	0	0	0.09
1991	0.3	0.9	0	0	0	0.24
% change, 1990-91	200	80	0	0	0	160.9

This experiment failed to provide testable results due to the very low beetle populations. Because the antiaggregative effects of MCH are well supported in the literature (Furniss et al. 1974, 1977, McGregor et al. 1984, Rudinsky et al. 1972) and potential for utilization in live Douglas-fir stands is high, I feel this experiment should be repeated insuring that the planned methods are followed.

Acknowledgment

I thank the staffs of the Weiser Ranger District and Forest Pest Management, Ogden and Boise Field Offices, for their assistance in experiment implementation and evaluation. Andy Gillespie, Northeastern Forest Experiment Station, provided statistical advice.

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United States Department of Agriculture | Forest Service | R-4

Reply to: 3420

Date: March 11, 1993

Subject: A Biological Evaluation "Efficacy of MCH to Prevent Spruce Beetle Infestation"

To: Chief, WO

Enclsed is a biological evaluation entitled "Efficacy of MCH to Prevent Spruce Beetle Infestation". For additional copies contact: Forest Pest Management
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for Ralph E. Williams

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Enclosure

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3420
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March, 1993

EFFICACY OF MCH TO PREVENT SPRUCE BEETLE INFESTATION

By

R. W. Thier[1]
Steve Munson[2]

Abstract

MCH, contained in plastic bubble caps, was released in stands of standing spruce at the rate of 40 bubble caps per acre. Although significant differences were not detected, trees in those plots treated with MCH sustained fewer spruce beetle attacks than did trees in untreated plots.

Introduction

Spruce beetles (Dendroctonus rufipennis (Kirby)) infest all species of spruce especially Engelmann spruce (Picea engelmannii Parry) in the central Rockies. Fallen spruces, often the result of windthrow, are preferred to standing trees. The infestations which develop in these fallen trees can precipitate widespread beetle outbreaks. (Schmid and Frye 1977).

Generally, adult beetles attack trees once annually with resulting broods taking 1-3 years to develop. Adults usually fly in June and July; bore through the bark and deposit eggs along galleries they construct in the phloem. Over the next 12-36 months following egg hatch the larvae feed in the phloem eventually girdling the host tree (Schmid and Frye 1977).

Both attractive and antiaggregative pheromones for spruce beetle have been tested and are used to manipulate populations of adult beetles. Schmid and Frye (1977) discuss these materials at length.

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Frontalin and alpha-pinene attract beetles and 3-methyl-2-cyclohexen-1-one (MCH) represses spruce beetle attack (Kline et al. 1974). Recently, Lindgren et al. (1989) reduced spruce beetle attack density and total beetle brood production in felled spruce using MCH released from plastic bubble caps attached to the fallen trees.

This investigation tested MCH, released from bubble caps, on standing uninfested spruce where beetles were present. The objectives of the test were to determine: (1) the efficacy of MCH to prevent spruce beetle infestation in the presence of spruce beetle baits containing frontalin and alpha-pinene, and (2) efficacy of MCH to prevent spruce beetle infestation in spruce stands.

Methods and Materials

Five replicates of four treatments were tested using a randomized block design. Treatments within each replicate consisted of: (1) spruce beetle bait, (2) MCH, (3) spruce beetle bait and MCH, (4) experimental control. Each treatment was applied to a 2.5 acre plot and replicated five times resulting in twenty 2.5-acre plots. Plots were square, five chains on a side, and spaced 5 chains apart.

The four plots within a replicate were as uniform as possible to minimize stand effects on the treatment. Spruce was to constitute 75% or more of the stand and plots were to contain 3-10 infested trees. Perfect uniformity was not essential because treatment effects were to be based on percent of trees infested.

MCH and baits were obtained from Phero Tech Inc.. Baits contained frontalin and alpha-pinene. MCH was loaded in plastic bubble caps which daily released 0.5 mg of MCH.

MCH bubble caps were evenly spaced throughout the plots in a grid pattern. Grid spacing was approximately 1/2 ch X 1/2 ch (40 caps/ac). Each cap was stapled to the bark, 6-7 feet above ground, on the north side of the tree that was closest to the grid coordinate regardless of tree species. Spacing was maintained as closely as possible.

Five spruce beetle baits were used in the baited plots. Baits were applied 6-7 feet above ground on the north side of a spruce 10" DBH or larger. One bait was placed at the center of the plot. The remaining 4 baits were placed at 90 degree intervals from the center bait approximatley 1 ch from the plot boundary.

In winter and early spring 1991, two replicates were established on the Payette National Forest, Idaho, and three on the Wasatch-Cache National Forest, Utah. Pheromones were deployed in April in advance of beetle flight.

In the fall of 1991, following beetle flight, all trees 5 inches DBH and larger were examined on all plots. Species and diameter of each tree were tallied. All tallied spruce were categorized as uninfested, killed prior to 1990, killed in 1990, or currently infested - 1991.

Data were tabulated and summarized. Means and 95% confidence intervals were used to analyze the data.

Results and Discussion

Pretreatment

Total stocking density ranged from 234 trees/plot to 1442 trees/plot (Table 1). There were no significant differences in total stocking density.

Spruce stocking density ranged from 127 trees/plot to 882 trees/plot (Table 1). There were no significant differences between treatments with respect to spruce stocking.

Table 1. Numbers of live trees >5" DBH on test plots before treatment.

Number of Live Trees

replicate	bait only	MCH only	bait+MCH	control
	treatments			
1 (Idaho)	419	254	234	241
2 (Idaho)	346	426	372	319
3 (Utah)	618	1383	614	1442
4 (Utah)	687	598	668	481
5 (Utah)	657	428	416	394
$\overline{X}$	545.4	617.8	460.8	575.4
S.E.	68.38	198.88	79.92	220.27

Number of Live Spruce

replicate	bait only	MCH only	bait+MCH	control
	treatments			
1 (Idaho)	127	156	190	163
2 (Idaho)	178	366	180	169
3 (Utah)	388	882	276	831
4 (Utah)	379	274	276	192
5 (Utah)	300	163	287	199
$\overline{X}$	274.4	368.2	241.8	310.8
S.E.	52.68	134.16	23.34	130.23

The baited plots averaged only slightly more than 49% live spruce, the control plots almost 54% live spruce, the bait + MCH plots 57% live spruce and the MCH plots 59% live spruce before treatment (Table 2). Only two individual plots met the 75% spruce stocking density minimum stipulated in the study plan. There was no significant difference in the mean live spruce makeup with respect to treatment.

Table 2. Percent of live spruce >5" DBH before treatment.

Treatment	Replicate 1	2	3	4	5	$\bar{X}$	S.E	95% conf. int. lower	upper
Spruce beetle bait	30.3	51.4	62.8	55.2	45.7	49.1	5.46	33.94	64.26
MCH	61.4	85.9	63.8	45.8	38.1	59.0	8.27	36.04	81.96
Spruce beetle bait + MCH	81.2	48.4	45.0	41.3	69.0	57.0	7.74	35.51	78.49
Control	67.6	53.0	57.6	39.9	50.5	53.7	4.52	41.15	66.25

From 0 to 28 trees per plot were killed by beetles before treatment. Most pretreatment spruce beetle activity was found on those plots treated by bait + MCH where an average 5.6 trees were infested (Table 3). Only 2 individual plots met the planned pretreatment standard of 3 to 10 infested trees per plot.

Table 3. Numbers of spruce trees >5" DBH attacked by spruce beetles on test plots.

Numbers of Spruce Attacked in 1990 Before Treatment

replicate	treatments: bait only	MCH only	bait+MCH	control
1 (Idaho)	0	0	0	4
2 (Idaho)	0	0	0	2
3 (Utah)	0	3	28	0
4 (Utah)	1	0	0	1
5 (Utah)	0	1	0	1
$\bar{X}$	0.2	0.8	5.6	1.6
S.E.	0.20	0.58	5.6	0.68

Numbers of Spruce Attacked in 1991 After Treatment

replicate	bait only	MCH only	bait+MCH	control
1 (Idaho)	4	0	1	58
2 (Idaho)	0	23	0	75
3 (Utah)	108	4	25	4
4 (Utah)	29	0	5	0
5 (Utah)	31	0	15	4
$\bar{X}$	34.4	5.4	9.2	28.2
S.E.	19.45	4.47	4.74	15.88

Post Treatment

Consistent with some literature (Dyer and Hall 1977, Kline et al 1974, Lindgren et al 1989) plots treated with MCH experienced less spruce beetle activity in 1991 than plots not treated with MCH. On average, the plots treated with MCH had 5.4 trees attacked and those treated with baits + MCH had 9.2 trees attacked. In contrast the control plots averaged 28.2 trees attacked while the baited plots had 34.4 trees attacked (Table 3).

To compensate for plot differences we converted data to percent attacked spruce (Table 4). The trend of percent spruce attacked was similar to the unconverted data. The average percent spruce attacked ranged from 1.3% in the MCH plots to 16.5% in the control plots; a greater than 91% difference. This finding is similar to that of Lindgren et al (1989) who reported an 85% reduction in spruce beetle attacks in the presence of MCH. The differences in percent spruce attacked however were not significant (Figure 1).

We found similar results when computing the percent change in attacked spruce from 1990 to 1991. On average all treatments experienced increased spruce beetle activity in 1991 but the percent increase was less in those plots influenced by MCH than in those plots without MCH influence (Table 5). The differences in percent change of attacked spruce were not significant (Figure 2).

Previous studies with MCH and spruce beetle were conducted using traps (Kline et al 1974), spruce stumps (Dyer and Hall 1977), and felled trees (Lindgren et al 1989). All these investigations showed that MCH effects a statistically significant reduction in spruce beetle activity. Our investigation is the first where MCH released from bubble caps was used in live spruce. Although similar to the above investigations, where MCH exhibited an influence, we cannot detect a significant reduction in activity. Perhaps the number of MCH releasers, in this case bubble caps, needs to be increased to achieve more consistent results.

Table 4. Percent live spruce >5" DBH mass attacked in 1991 by treatment.

Treatment	Replicate 1	2	3	4	5	$\bar{X}$	S.E	95% conf. int. lower	upper
Spruce beetle bait	3.15	0	27.83	7.65	10.33	9.792	4.849	-3.669	23.253
MCH	0	6.28	0.45	0	0	1.346	1.237	-2.087	4.779
Spruce beetle bait + MCH	0.53	0	9.06	1.81	5.23	3.326	1.698	-1.389	8.041
Control	35.58	44.38	0.48	0	2.01	16.490	9.696	-10.426	43.406

Figure 1. Percent Spruce Attacked in 1991
mean +/- 95% confidence interval

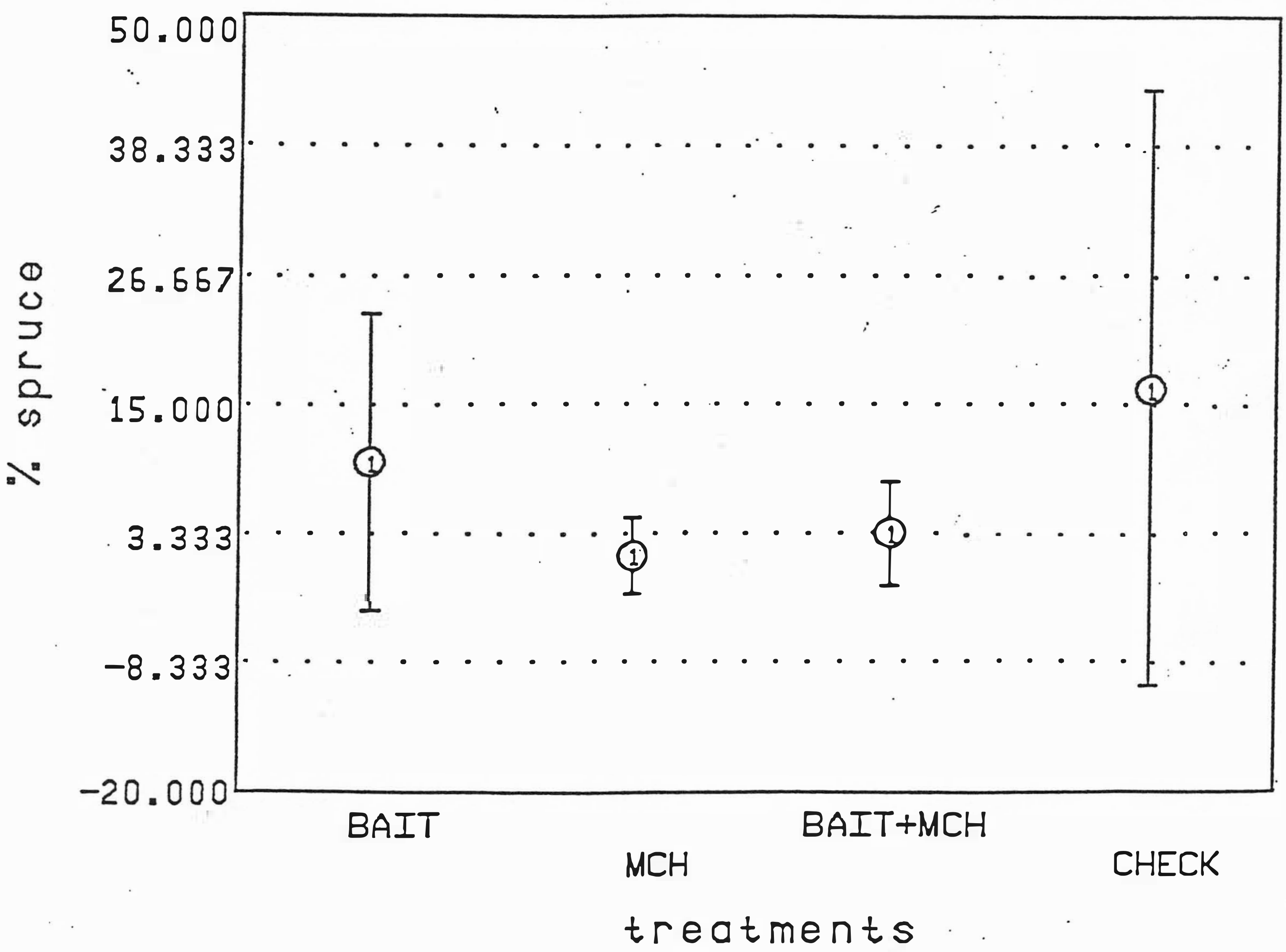
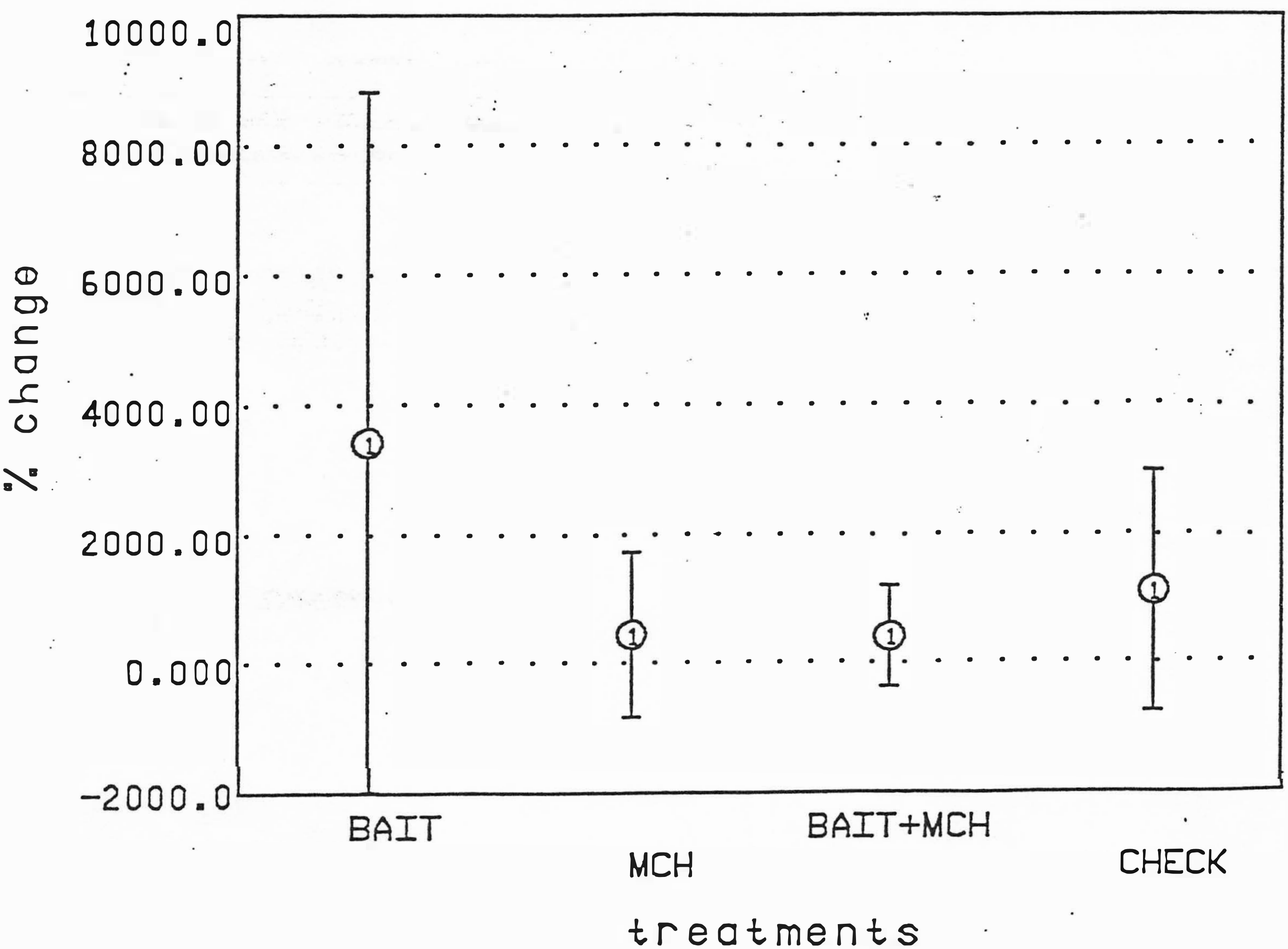


Table 5. Percent change in number of attacked spruce from 1990 to 1991 by treatment.

Treatment	Replicate 1	2	3	4	5	$\bar{X}$	S.E	95% conf. int. lower	upper
Spruce beetle bait	400	0	10,800	2800	3100	3420.0	1946.38	-1983.15	8823.15
MCH	0	2300	33	0	-100	446.6	463.89	-841.16	1734.36
Spruce beetle bait + MCH	100	0	-11	500	1500	417.8	286.12	-376.47	1080.39
Control	1350	3650	400	-100	300	1120.0	675.76	-755.91	2995.91

Figure 2. Percent Change Attacked Spruce 1991
mean +/- 95% confidence interval



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